U.S. Fish and Wildlife Service
U.S. Department of the Interior

National Wildlife Refuge System

National Protocol Framework for the Inventory and Monitoring of Migratory Shorebirds

ON THE COVER
Migrating Red Knots and Short-billed Dowitchers, Monomoy National Wildlife Refuge, Massachusetts
Photograph by: Brad Winn

NWRS Survey Protocol Signature Page

Protocol Title: National Protocol Framework for the Inventory and Monitoring of Migratory Shorebirds

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Approvals

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Version[1]	**Date**	**Author**	**Change Made**	**Reason for Change**

[1] Version is a decimal number with the number left of decimal place indicating the number of times this protocol has been approved (e.g., first approved version is 1.0.; prior to first approval all versions are 0.*x*; after first approval, all minor changes are indicated as version 1. *x* until the second approval and signature, which establishes version 2.0, and so on).

[4] Signature by Regional I&M Coordinator signifies approval of a protocol framework to be used at multiple stations within a Region.

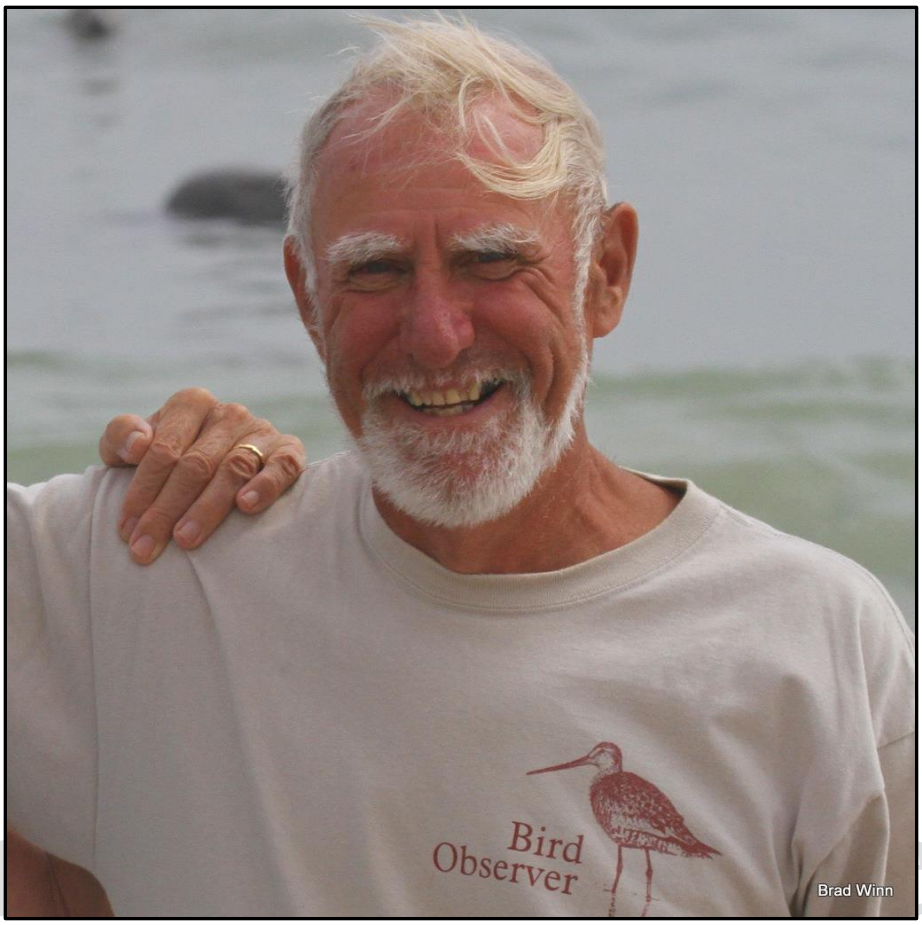
[5] Signature by National I&M Coordinator signifies approval of a protocol used at multiple stations from two or more Regions.

Survey Protocol Summary

The majority of shorebird species (52) found nesting in North America spend most of each year in non-breeding habitats (nine months or 75%) while either migrating, or on over-wintering grounds. The longest distance migrants of this group fly to and from their brief nesting seasons in northern Canada and Alaska. Declines in migrant shorebirds during the 1980's and 1990's have generally stabilized in recent years Trend data derived from International Shorebird Survey (ISS) and other sources indicate continued long-term declines in at least seven species. However, the authors caution that 25% of North American shorebirds have no population data at all, and more long-term survey data are needed. Shorebird trends throughout the world show declines in the majority of species. The National Wildlife Refuge system is playing an increasingly crucial role in maintaining, managing, protecting, shorebird habitat throughout the country. Understanding the temporal and spatial shorebird use patterns will be important to maximize stewardship potential on each refuge while contributing to gaps in population trend data nationally. The protocol described in this document is meant to be used to monitor migrating and wintering shorebirds in all potential habitats within a refuge. The design is similar to that laid out by the Program for Regional and International Shorebird Monitoring (PRISM). PRISM outlines a systematic approach to sampling while the survey methods are compatible with the traditional ISS. The primary goal is to estimate the number of shorebirds utilizing stopover sites during the spring and fall migration. These sites can then be more effectively managed to conserve focal species on a regional or local level. The sampling frame is defined as all potential shorebird habitats within a refuge. These areas are then divided into plots. The sampling unit is defined as a plot at a particular point in time. Data are recorded at the plot level. Spring counts should be made from March through June and fall counts are July through October. The winter season, if being surveyed is November to March. Surveys can be conducted once every ten days, which is the preferred timing. Alternatively, plots can be surveyed three times a season with the surveys spaced according to the schedule outlined in SOP #2. Surveys should be consistently conducted either two hours before and after high tide or low tide. Shorebird data collected with this protocol should be entered into the Avian Knowledge Network database.

Suggested citation:
Schmidt S R and Winn B. 2014. U.S. National Protocol Framework for the Inventory and Monitoring Migratory Shorebirds. Natural Resources Program Center, Fort Collins, CO.

This protocol is available from ServCat [http://ServeCat.doc.location]



Brian Harrington, Monomoy National Wildlife Refuge, Sept. 2012

Acknowledgments

We extend our most sincere gratitude to Dr. Jon Bart for his significant contributions to the ISS/PRISM protocol in this report and continued support of Manomet's conservation efforts. We also thank Brian Harrington whose commitment to shorebird science drove him to conceive, launch, and coordinate ISS over the last three decades. Brian's considerable efforts have advanced our collective understanding and appreciation of shorebird migration in the Western Hemisphere more than any other individual or institution.

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Element 1: Introduction

The majority shorebird species found nesting in North America spend most of the year in non-breeding habitats both during migration and over-wintering. Thirty-five of these mostly wetland-dependent species migrate long distances to and from their brief nesting seasons in northern Canada and Alaska to more temperate or tropical wintering areas. Distances these birds fly can be as far as 11,000 miles between seasonal destinations. Many of the species that fly these distances use long-hop migration strategies, relying on specific food-rich wetland locations to stop, rest, and replenish body weight before flying the next flight segment. Migration stopover patterns appear as a series of Western Hemisphere stepping stones, with hundreds or thousands of miles separating each stop (Harrington et al. 2002).

The National Wildlife Refuges are playing an increasingly crucial role in maintaining, managing, protecting, and in some cases recreating these stepping stone wetland habitats that support shorebirds throughout the country. Understanding the temporal and spatial shorebird use patterns will be important to maximize stewardship potential on each individual refuge.

This survey protocol framework was modeled after the commonly used protocols developed for the International Shorebird Survey (ISS) and Program for Regional and International Shorebird Monitoring (PRISM) surveys. The framework will give managers, biologist, and citizen science volunteers a template on how to record shorebird use of their particular refuge, where to record the data, and guide the managers in how to analyze the data in order to make informed local wetland management decisions for shorebird conservation. The ISS/PRISM survey protocols are expected to integrate well with the fledgling Integrated Waterbird Management and Monitoring (IWMM) currently being developed by for the Atlantic and Mississippi flyways. Please refer to the IWMM team website at http://iwmmprogram.ning.com or for specific questions directly to Brian Tavernia iwmmprogram@gmail.com.

Background

In 1974 Manomet Center for Conservation Sciences, led by Brian Harrington, developed the International Shorebird Surveys (ISS) to gather basic migration information on shorebirds and the wetlands they use. Brian and Manomet recognized that there were considerable gaps in knowledge of this understudied group of birds. The ISS and later the sister program Atlantic Canada Shorebird Survey, set out to see what shorebirds species were migrating in what numbers in which of the flyways. Data collected by volunteers from over 50,000 shorebird counts, at more than 600 sites reaffirmed that many species of shorebirds depend on a finite number of migration staging sites within the year. These results drew attention to the importance of specific refueling stops for shorebirds, and eventually led to the establishment of the Western Hemisphere Shorebird Reserve Network (WHSRN), one of the longest running conservation strategies in the country.

ISS data are used principally for conservation and management initiatives. But have also been used to identify sites in North and South America that qualify for inclusion in the Western Hemisphere Shorebird Reserve Network (WHSRN), for charting migration timing at key sites,

and for developing an atlas with basic information regarding shorebird migration ecology. ISS evaluations have helped formulate practices and inform training programs in federal agencies as varied as the U.S. Forest Service, the Department of Defense, and the U.S. Fish and Wildlife Service, as well as dozens of state agencies.

Data from ISS and other sources indicate there have been long-term declines in many species and within populations in North America (Andres et al. 2012) and other data sources indicate some major shorebird declines throughout the world (Zockler et al. 2012). The National Wildlife Refuge system is perhaps the best platform in the U.S. on which to monitor shorebird abundance and trends. Refuges have the ability to commit to long-term population survey data collecting that is needed to understand population vulnerabilities with such seasonally ephemeral migrants like shorebirds.

An important goal of the ISS is to have an operational monitoring program that provides reliable data about distribution and trends in shorebird populations for decades. Crucial to this goal are low costs, operations on a broad geographic scale, and competent personnel. Costs of paying for this work would be prohibitive, so the ISS is developed around a volunteer base to gather needed information. When followed, this survey protocol framework will help provide reliable information to assist decisions on shorebird conservation and management.

Objectives

Management objective: The recently completed Atlantic Flyway Shorebird Conservation Business Strategy has set a population objective of increasing shorebird populations using that flyway by 10-15% by 2020 (http://www.manomet.org/atlantic-flyway-shorebird-conservation-business-strategy). Species priorities and population trends will vary by Flyway, creating the need for regionally specific management objectives. By expanding and integrating wetland acres and management protocols for shorebirds within the National Wildlife Refuge system, the Atlantic Flyway Conservation Business Strategy population targets can be stepped down and customized at the regional level within all flyways. The local conservation targets and actions should be prioritized by regional biological refuge teams.

Sampling objective: Each refuge or refuge complex will develop its own ISS sampling objectives based on regional shorebird conservation goals. The fundamental attribute that will be measured by observational counts is the number of shorebirds by species and strata within a refuge for a given time period.

1. All species of shorebirds using the plots in the refuge will be surveyed;
2. Shorebird surveys will be conducted on plots within the refuge on likely habitat, including open wetlands in fresh, brackish and saltwater. Managed impoundments, mud flats, sand flats, and shallow water environments attract shorebird use;
3. Shorebirds are to be counted or estimated by species;
4. The target response should be annual trends in shorebird use of managed and unmanaged refuge habitats;
5. Shorebirds tend to respond rabidly to newly exposed or available wetland habitats in response to impoundment drawdowns or protection from human traffic, especially on beaches. So some levels of response can be expected within days of management action made during migratory periods.

6. Shorebird counts or estimates should be as accurate as possible, and surveyors can practice estimating well in advance of the survey periods to improve estimating accuracy.

Element 2: Sampling Design

This protocol is meant to be used to monitor migrating and wintering shorebirds in all potential habitats within a refuge. The design is similar to that laid out by the Program for Regional and International Shorebird Monitoring (PRISM), a program that has built upon the International Shorebird Survey (ISS) and is described in SOP 1: Sampling Design. PRISM outlines a systematic approach to sampling while the survey methods are compatible with the traditional ISS. The primary goal is to estimate the number of shorebirds utilizing stopover sites during the spring and fall migration (Thomas 2005). Monitoring can provide land managers with information on key locations within their refuge. These sites can then be more effectively managed to conserve focal species on a regional or local level.

Sampling units, sample frame, and target universe

The sampling frame is defined as all potential shorebird habitats within a refuge. These areas are then divided into plots. The sampling unit is defined as a plot at a particular point in time. Data is recorded at the plot level. Plot sizes can vary in size and shape. Here is an example of a plot (in red) from the Wolf Island National Wildlife Refuge on the Georgia Coast:

Figure 1. Plot GA-45 on the Wolf Island National Wildlife Refuge (beach strata).

Plots should meet the following four criteria:

1) The plot is consistent with management objectives or existing monitoring areas,
2) Plots should be easy to survey,
3) It should be feasible to survey a plot within one survey window which can depend on tide when applicable.
4) Plots should be delineated according to the intensity of shorebird use.

In situations such as coastal inlets, where the dynamic nature of the site will create continual change, plot boundaries should be fixed points that reflect this expected change, and be large enough to incorporate shorebird use over time. Plots should generally only include one side of an inlet unless the inlet is small and both sides can be surveyed easily on one survey event.

The target universe depends on the management objectives. The ISS/PRISM program is designed to estimate and monitor shorebird populations using non-breeding surveys. Ideally, the mean number of birds present is estimated on a regional scale for inferences to be made at that level. In some cases (Atlantic States coastal refuges), regional sampling frames have been developed, but on most refuges, the target universe is strictly within-site. Changes in shorebird numbers will be made on a refuge by refuge basis without inference to population trend, unless they are part of a larger sampling frame. Check to see if there are any regional-scale shorebird surveys in the area that the survey could be coordinated with. Coastal ISS surveys are conducted at either high or low tide to avoid double counting. Local conditions will determine timing.

Sample selection and size

Generally plots are stratified according to the number of birds expected based on historic observations in the area (strata and proximate vicinity) (Thomas 2005) but also can be stratified according to management objectives. Determination of strata is based on the proportion of shorebird days (one shorebird spending 24 hours within an area) within a plot (Bart et al. 2005). Type 1 or "to be surveyed" strata are plots with high shorebird use or are plots to be surveyed because of a management interest. Type 2 strata have birds present in smaller numbers and Type 3 plots are areas with virtually no shorebirds.

The sample selection of plots within each strata can either be random or systematic. Two plots within each stratum should be surveyed. The number of additional plots counted will depend on resources allocated to surveys. Typically, all Type 1 plots should be surveyed. The Type 2 and Type 3 plots can be determined by random selection. This design can be revisited if a shift in shorebird use is detected. Sample size depends on the survey objectives and the number of surveys that can be realistically delivered.

Survey timing and schedule

Spring counts are made from March through early June and "fall" counts are July through October. The winter season, if being surveyed is November to March.

Survey times should be selected systematically throughout the migration season. Surveys can be conducted once every ten days, which is the preferred timing. The ten day interval was chosen as the approximate length of stay at a stop-over site (Howe, Geissler and Harrington 1989). With survey visits spread through the season, peak migration stopover numbers should be captured.

Alternatively, plots can be surveyed three times a season with the surveys spaced according to the schedule outlined in SOP 2: Conducting Surveys.

Surveys should be consistently conducted either two hours before and after high tide or low tide if circumstances favor low tide survey visits. This avoids double counting birds that move to different habitats depending on the tide.

Surveys should only include the birds present at the start of the survey. Birds entering the survey area are excluded from the official count. This can be challenging if the birds leave before the surveyor can count them.

Sources of error

Measurement error/bias could occur in area where habitat and uneven topography interfere with detectability of birds. For instance, vegetation within mudflats may screen birds making them impossible to locate (Byrne et al. 2009). Some species may prefer more vegetated areas thus biasing the count towards the more visible species (Thomas 2005). Additionally, areas disturbed by human use could affect the survey. Bias can occur if good shorebird habitat is inaccessible to the surveyor. Measurement error/bias could also occur with varying observer abilities or if the survey is attempted during a severe weather event.

Element 3: Field Methods and Sample Processing

Pre-survey logistics and preparation

Shorebird identification skills, as well as training in estimating large numbers of birds should be practiced by biologists and volunteers well in advance of the initial surveys. An excellent tool for counting and estimating groups of birds, mammals, and fish is available at (http://www.wildlifecounts.com).

Shorebird surveys are conducted within predetermined, plots that have been mapped with GIS or remote sensing software. Sampling is either done from one "stationary" location, or by "traveling" as when the observer walks a beach. In impoundments on a refuge, multiple plots can be sampled in a "traveling" survey effort or from a "stationary" point such as an observation platform or corner between wetland units. Criteria for point selection are that they provide 1) an unobstructed view of the plot, 2) as a whole, provide total coverage of the plot and, 3) are safe and reasonably easy to get to.

Field equipment should be organized and tested prior to the field season. The list of equipment is provided in Table 1.

Table 1. Equipment and materials necessary to conduct shorebird surveys.

EQUIPMENT	DATA COLLECTION
Binoculars	Site Map/Plot Map
Spotting Scope (preferably with weather protection)	Data Form
Field Guide	Pen
	Protocol
	Clipboard

Plot areas are mapped and determined using GIS or remote sensing software. The plot area is delineated as a polygon on a satellite view of the area so that land forms and other identifying features can be noted. Survey points are also delineated. The plot name and plot area should be printed out for surveyor use. See Figure #1 for example of a plot.

Data forms are created and printed out for surveyor use. A Refuge may wish to create their own data form based on one that they have used in the past or to incorporate new management objectives. Data forms should include all fields required by the ISS (see *Data Management section*). An ISS Survey Form is provided in Supplemental Materials 2.

Compile and assemble data collection materials prior to surveys. These data-collection packets will include the site-specific survey protocol and data forms. Detailed data entry instructions with the Project Username and email should also be included. Similar packets can be included with any other training guidance (see Personnel Requirements and Training).

Establishment of sampling units

Plot boundaries are delineated on a map or by GIS. The plot name and area are also shown on the map to be used for data entry. In addition to the map, a number of means can be used to direct the surveyor to the site and to survey points. These include written directions and GPS coordinates. Survey stations can be indicated by flagging or by permanent markers such as a boulder or other permanent structure. Please see SOP 1, Sampling Design, plot borders.

Data collection procedures (field, lab)

This protocol requires a surveyor to count and record all shorebirds within a plot. The plot may be accessed by foot, vehicle, boat or plane as long as the entire plot is covered within a survey period. Only birds present at the start of the survey are recorded. Additional details regarding data collection can be found in the SOP 2: Conducting Surveys.

For each species observed and counted, surveyors need to record an accuracy statement of their count (e.g. was the count an absolute count, a relative count with the flock bracketed into smaller groupings, or a guess of flock size based on experience), tide or water level at the start of the count, disturbance, and start time and count duration.

End-of-season procedures

Instead of waiting until the end of the survey season, field data should be proofed and entered into electronic format as soon after each survey as possible, preferably the same day to clear-up inconsistencies or questions. For the actual end-of-season procedures, please include clean-up and storage of any field equipment; reproof and archive data; analyze data and draft an annual report; and please submit survey plot maps to the ISS if not done during the season. Additionally, if permits were required to access parts of the Refuge or private lands, then appropriate reports are required.

It is suggested that, especially if using volunteers, that an end of season wrap-up meeting be considered. This is a good way to gather information about needed improvements for the next season and to express appreciation for a job well done by the volunteers.

Element 4: Data Management and Analysis

Since the eBird database does not store covariate data along with the observational shorebird data, we are investigating means to store shorebird data in the Avian Knowledge Network (AKN). Once this is determined, we will update the procedures for data management and storage here and in SOP 3: Data Processing.

Data entry, verification, and editing

Enter data as soon as possible following a plot survey visit. It is very important to have a second person familiar with the survey protocol to thoroughly review the field sheets prior to data entry. Establish a schedule for this review check of field data. If the review and data entry are left too long, some questions regarding species ID, erroneous numbers, or indecipherable numbers or text might be lost. It is helpful to use different colored ink for the review from that used in the original field work. Data checkers should initial and date the review of survey data.

Metadata

Metadata provide descriptive information about the data that was collected including how it was collected, who collected it, and data field and attribute definitions. Documentation of biological metadata should follow the U.S. Fish and Wildlife Service's standards as set forth by the FGDC Biological Data Working Group, and USGS Biological Resources Division (1999) and described by Executive Order 12906 as amended by Executive Order 13286 (Federal Geographic Data Committee 2000; US Fish and Wildlife Service. 2013). Metadata should be archived with original data. In most cases, the site-specific survey protocol will provide this information and a copy of the protocol can be stored on site with the original data.

Data security and archiving

Hardcopy and electronic survey data, field notes, and plot maps will be archived in compliance with relevant Service data standards (http://www.fws.gov/stand/) and Refuge System Policy (701 FW2). Data sheets should be proofread, scanned and archived in ServCat as a digital holding of a relevant annual report. Corrections should be made to the copied data before data entry. Field notes may optionally be scanned and archived in ServCat in the same manner. The ServCat metadata record for each report-data holdings should be cross-referenced to the guiding site-specific survey protocol. Original electronic and hardcopy data should also be stored in a secure manner. This will provide three locations of the collected data, AKN, ServCat, and at the surveyed refuge.

Electronic data should be archived according to the Service's Policy on Electronic Records (282 FW4; http://www.fws.gov/policy/282fw4.html). This requires that metadata describing the data, collection procedures, data quality, quality control parameters, formats, and storage locations should be documented and a hardcopy stored with the original data sheets. A copy or link to the site-specific survey protocol will typically provide the needed information.

Analysis methods

SOP 4: Data Analysis, describes how to use these surveys to estimate the mean number of birds present in the study area during the study period and to estimate trends in this mean, especially across a series of years. Analysis depends on the number of plots surveyed in the target universe.

If all plots in the target universe are surveyed on the same day, then the estimated mean number of birds is the mean of the survey totals and the estimated standard error is the square root of the variance of the counts divided by the number of counts.

If all plots are surveyed but on different days, then the estimated mean number of birds is the sum of the mean number of birds in each plot. If only some plots in the target universe are sampled, then the plots need to be grouped by strata and number of plots within each stratum is used in the estimation process.

Additional analysis of the data will be dependent upon management and sampling objectives.

Software

All analyses can be accomplished in basic spreadsheets or with programmable statistical software (e.g., SAS; R).

Element 5: Reporting

These reporting and archiving instructions are adapted from the Landbird Monitoring Protocol (Knutson 2008) and provide basic procedures based on U.S. Fish and Wildlife Service standards. Each refuge may have additional procedures depending on underlying survey objectives. Reporting includes providing written summaries of survey findings, documentations of events that may have influenced the data, and archiving of raw data in addition to procedures described under Data Management and Analysis. For those surveys conducted to support management, implications and how the results inform those management activities should also be reported.

Implications and application

An annual report should be produced for each year that a survey using the protocol is conducted to count shorebirds. This report is in addition to the reporting of data using AKN (see *Data entry, verification, and editing*).

Objectives and Methods –

The objective of an annual report is to summarize the results of the annual shorebird monitoring (initial inventory if it is the first year of survey) at the refuge and to document deviations in the survey protocol. This would include information about shorebird use of the refuge, changes in site-specific use over time or with management activities, and management implications, when possible. Periodic and final synthesis of the results provided in the annual reports will likely provide more meaningful information on trends in shorebird numbers and local use. If additional types of data are collected, then the appropriate summary information is required according to the stated objectives. Data uploaded to AKN will be used to establish trends in shorebird populations and migration pathways at broader scales.

Summary of Results –

In addition to reporting the information obtained by analyzing the data to estimate the mean number of birds in study area as described in Element 4: Data Management and Analysis,

descriptive summary statistics may be useful especially for species of concern to the refuge or the flyway.

Important Findings –

Findings can be compared to prior year statistics to determine the magnitude of changes, if any, that have occurred in survey areas. The importance of findings will vary according to the management objective.

The following list of items that should be included in a report is adapted from How to develop survey protocols: a handbook by US Fish and Wildlife Service (2013):

1. Title: Include these three items: a) Name of the survey, b) Survey ID, and c) Date that the survey was conducted.
2. Authors: Identify names, affiliations and contact information.
3. Date prepared: Provide the date of the report.
4. Objectives: Include the management and sampling objectives identified in the survey protocol.
5. Methods: Provide a complete description of survey and data analysis methods, citing the appropriate survey protocol will usually suffice. Add descriptions for methods not covered in the protocol.
6. Results: Describe the number and types of samples collected and present data summaries.
7. Problems encountered: Describe any difficulties with the data collection or analysis, including departures from the methods in the survey protocol.
8. Important findings: Interpret the results of the survey with respect to the management objectives or decisions that must be made. Discuss reliability of the results and provide conclusions and any recommendations.

Reporting schedule

Annual field season summary reports are recommended in order to monitor site- and refuge-specific shorebird observations (Byrne 2009). Additional reports, for instance reports for funding sources or the Refuge Report Series should be produced as necessary. Data should be reported annually to the ISS database as described in SOP 3: Data Processing, and electronic or hard copies of survey site maps should be archived annually.

Report distribution

Summary reports should be distributed internally as necessary. Data should be reported to the ISS via the AKN portal. Electronic or hard copies of survey site maps should be sent annually to Brad Winn (bwinn@manomet.org), Manomet Center for Conservation Sciences, P.O. 1770, Manomet, MA 02330, ATTN: ISS).

Element 6: Personnel Requirements and Training

The Refuge may choose to utilize personnel on staff to conduct the surveys; they may hire a seasonal technician or recruit volunteers. Recruitment should take place well before the field season to allow time for training and for paperwork and permits, if necessary, to clear.

Volunteers may be recruited to conduct the surveys. Extremely knowledgeable and willing participants are the basis of the ISS in general and can be very effective and loyal if conducting

work for the refuge "in their back yard." A volunteer coordinator is strongly suggested to manage and coordinate volunteers. One tool that is available for training both volunteers and biologists to count shorebirds is a program that can be ordered here (http://www.wildlifecounts.com).

Roles and responsibilities

The number of sites to be surveyed and budget will determine the number of personnel or volunteers required to complete the survey. The survey coordinator, usually a Refuge Biologist, will be responsible for ensuring that the site-specific survey protocol is followed. When the number of people, paid staff or volunteers, helping to implement the survey becomes large it will be helpful to assign someone from the crew to assist the survey coordinator, particularly in data collection and management.

Qualifications

The skills required for a surveyor position include a willingness to learn; ability to identify to species shorebirds in winter, spring, and transitional plumage; ability to walk long distances, deal with adverse weather, and spend long hours in the field; and have a meticulous eye for detail. Skills may also include the ability to work with spreadsheet programs and online data entry systems.

Training

Technicians/volunteers will need to be trained in identification of shorebirds in breeding, transition, and winter plumage, proper implementation of the survey protocol, skills and strategies to count large flocks of shorebirds. Contact the Manomet Center for Conservation Sciences for assistance in building these skills. Data management personnel may need instruction in data formatting and entry into the online data entry system or spreadsheet. Training aids such as Wildlife Counts, a program that allows one to practice estimating or counting large flocks, provide structured learning and performance feedback.

Safety training may be in order in areas with ticks, venomous snakes, or poisonous vegetation. Training will also be necessary if vehicle, radios and/or GPS devices are used. The types of training needed by employees or volunteers will also vary by the environment encountered at a refuge or in a particular region. These training requirements should be spelled out in the site-specific survey protocol.

Volunteer services agreements (150 FW 1; FWS 2003) must be completed, when necessary. Also, permits may be required for personnel/volunteers to enter closed areas of the refuge.

Element 7: Operational Requirements

Budget

Budget considerations will depend upon the size of the refuge and the number of plots to survey. Costs include the cost of equipment, project leader time, and field technician time (See Table 2). Additional costs may include housing and vehicle operation and maintenance. Mileage reimbursement should be considered if using volunteers.

Table 2. Example estimate of survey costs for refuge.

PHASE	STATION PERSONNEL	STAFF TIME (FTE)	EQUIPMENT & CONTRACTS	OPERATION COSTS
Collect Data	1-2 staff	144 hrs/yr	N/A	$4,000 (incl. fuel costs)
Analysis	1 staff	8 hrs/yr	N/A	$500
Report	1 staff & 1 vol.	40 hrs/yr	N/A	$2,500
Total	--	**192hrs/yr**	**--**	**$7,000/yr**

Staff time

Staff required will depend on whether technicians are hired or volunteers recruited and the level of survey effort. Staff will be necessary early in the year to begin the employment process for technicians or to recruit volunteers. Volunteers may be sought through refuge Friends groups, local birding clubs, known area birders, and local or state environmental divisions.

In preparation for the field season, staff time is required to define and stratify sampling units or plots, delineate the boundaries of each plot on maps, draft a working version of the field and data entry protocol, design a training program and schedule surveys. During field season staff will need to coordinate surveys, maintain contact with technicians or volunteers and respond to issues as they arise. At the end of the field season, staff is needed to clean and store field equipment, manage data entry, analyze data, and write-up an end of season report. If using volunteers to conduct the surveys, it is strongly suggested that a report/newsletter be issued that summarizes the data analysis and acknowledges their effort in a successful season.

Coordination

Coordination with other agencies or organizations may be necessary depending on the Refuge's situation and geographic location. In some states there are ISS Survey Coordinators available at various levels of assistance from recruiting surveyors to training surveyors to conducting surveys (e.g. Maine Inland Fisheries and Wildlife, New Jersey Audubon, and State of Delaware Fish & Wildlife Shorebird Project). Coordination with these organizations and agencies will depend on the Refuge's need.

Element 8: References

Andres BA, Smith PA, Morrison RIG, Gratto-Trevor CL, Brown SC, Friis CA. 2012. Population estimates of North American shorebirds, 2012. Wader Study Group Bull. 119(3): 178–194.

Bart J, Andres BA, Brown SC, Donaldson G, Harrington B, Johnston V, Jones S, Morrison RIG, and Skagen S. 2005. The Program for Regional and International Shorebird Monitoring (PRISM). Pages 983-901 in Ralph, C.J. and T. D. Rich (editors). Bird conservation implementation and integration in the Americas: Proceedings of the Third international Partners in Flight conference. General Technical Report PSW-GTR-191, U.S. Department of Agriculture Forest Service, Albany, California.

Byrne MW, DeVivo JC, Maxfield JM, Wright CJ, Thompson E. 2009. Methods for monitoring migratory and wintering shorebirds in Southeast Coast Network Parks. Natural Resource Report NPS/SECN/NRR—2009/107. National Park Service, Fort Collins, Colorado.

Executive Order 12906. 1994. Coordinating geographic data acquisition and access: The National Spatial Data Infrastructure. Federal Register 59(71):17671–17674.

Executive Order 13286. 2003. Amendment of executive orders, and other actions, in connection with the transfer of certain functions to the Secretary of Homeland Security. Federal Register 68(43):10619–10633.

FGDC Biological Data Working Group and USGS Biological Resources Division. 1999. Content Standard for Digital Geospatial Metadata - Biological Data Profile, FGDC-STD-001.1-1999 Federal Geographic Data Committee. Washington, D.C. Available: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/biometadata/biodatap.pdf (accessed Aug 2013).

Harrington BA, Brown SC, Corven J, and Bart J. 2002. Collaborative Approaches to the Evolution of Migration and Development of Science-based Conservation in Shorebirds. Auk. 119(4):914-921, 2002.

Howe MA, Geissler PH, Harrington BA. 1989. Population Trends of North American Shorebirds Based on the International Shorebird Survey. Biological Conservation 49: 185-199.

Knutson MG, Danz NP, Sutherland TW, Gray BR. 2008. Landbird Monitoring Protocol for the U.S. Fish and Wildlife Service, Midwest and Northeast Regions, Version 1. Biological Monitoring Team Technical Report BMT-2008-01. U.S. Fish and Wildlife Service, La Crosse, WI. 25 pages + 11 Standard Operating Procedures.

Thomas S. 2005. Temperate non-breeding surveys --- A key to shorebird conservation. Pages 918-923 in Ralph, C.J. and T. D. Rich (editors). Bird conservation implementation and integration in the Americas: Proceedings of the Third international Partners in Flight conference. General Technical Report PSW-GTR-191, U.S. Department of Agriculture Forest Service, Albany, California.

US Fish and Wildlife Service. 2013. How to develop survey protocols: a handbook. National Wildlife Refuge System, USFWS, Natural Resource Program Center, Fort Collins, CO.

Zöckler C, Lanctot R, Brown S, Syroechkovskiy E. 2012: Waders (Shorebirds) [in Arctic Report Card 2012], http://www.arctic.noaa.gov/reportcard.

Standard Operating Procedure 1: Sampling Design

This SOP describes a sampling design for conducting nonbreeding shorebird surveys that monitors use at managed and unmanaged wetland sites within a refuge, provides information on habitat relationships during spring and fall migration, and helps local managers meet their shorebird habitat and population goals. 1. All species of shorebirds using the plots in a refuge will be surveyed; 2. Shorebird surveys will be conducted on plots within the refuge on likely habitat, including open wetlands in fresh, brackish and saltwater. Managed impoundments, mud flats, sand flats, and shallow water environments attract shorebirds. 3. Shorebirds are to be counted or estimated by species;.

Sampling unit

The sampling units are defined in space and time; they may be thought of as a "plot-time," that is, a defined plot at a particular point in time. We discuss the two "dimensions" of the sampling unit below.

Plot borders –

Four criteria may be used in defining plot borders.

First, plot borders should be consistent with management objectives. For example, if the plots are in controlled impoundments, and the impoundments are managed separately, then a plot should probably not include more than one impoundment. Data will not generally be recorded below the plot level so if one plot covered two impoundments it would not be possible to determine later how many birds were in each impoundment.

Second, plots should be easy to survey. For example, plots on the coast, at the mouth of a river, should not extend across the river unless it is easy to drive around the river or birds on both sides can be seen from one side of the river. On a coastline with few access points, the plots would usually extend between access roads, so the surveyor could walk from one end to the other and then be picked up, or the borders would be mid-way between access roads if the surveyor was going to walk up and back. In general, one would not delineate a series of beach plots stretching away from a single access point because if surveyors were going to walk to the farthest plot, they could just as easily count birds throughout the entire stretch of beach. People familiar with the areas will find many other ways to make the plots as easy as possible to survey.

Third, plots should be feasible to survey during one visit. If surveys are to be made during a given period with reference to tides (e.g., within two hours of high tide), then the surveyor or survey team must be able to complete the survey within the survey window. There is no need, however, for plots to be the same size. Plots surveyed on foot will generally be much smaller than plots surveyed by vehicle. If a boat is used to reach plots, and a team of surveyors is present, then the plot may be quite large and could include several islands.

Fourth, when feasible, plots should be delineated to maximize the difference in numbers of birds. That is, try to design the plots so some plots have lots of birds and the others have few birds. One reason for doing this is that sampling intensity can then be higher in areas with many birds so

that the "good places" will be well-surveyed. Stratification is used to ensure that – even though surveys are concentrated in good areas – an unbiased estimate is obtained of the mean number present throughout the study area (see *Sampling plan and sample selection* below).

Survey times –
The temporal dimension of the survey is usually defined as a single point in time so that the mean number present may be estimated. The mean number present times the number of days in the survey period equals the number of bird-days (i.e., one bird-day equals a bird in the study area for one day) which facilitates comparison of different areas and may be used, in the ISS/PRISM program for monitoring trends in shorebirds using counts during the non-breeding survey. In contrast, if surveyors count all birds present in the plot at any time during the survey then the number recorded cannot easily be used to estimate mean number present. Furthermore, the count has undesirable statistical properties. For example, its value tends to increase with survey duration because the longer the count the more birds enter the plot. This means that if survey duration changes, counts will probably change even if the mean number of birds in the survey area does not change.

Defining the sampling unit as a plot-point in time means that birds which enter the plot after the start of the survey should not be included in the official count, though they can be recorded as incidental birds. On the other hand, birds present at the start of the survey that fly away should be counted which may be challenging if they leave well ahead of the surveyor. When this is a danger, the plot can be sub-divided into compartments – as described above – that are then surveyed sequentially.

The temporal dimension usually includes time of day restrictions. For example, surveys may be conducted during working hours within two hours of a high tide.

Target universe (inferential population)
This is the area and period of time to which statistical inferences will be made. Two broad program objectives – which dictate very different target universes – should be distinguished. One objective, is documenting, describing and monitoring use by shorebirds of the study area during the study period. This is a typical objective for Refuges and other areas managed for birds and in programs designed to ensure that shorebirds are finding suitable habitat in areas managed for multiple use (e.g., beaches). For this objective, the target universe will usually be all areas used by shorebirds and all times at which the areas are used.

A second objective is to participate in the ISS/PRISM program designed to estimate and monitor shorebird populations using non-breeding surveys. This survey uses data from all participating locations to estimate the mean number of birds present throughout the large study area during the study period. Additionally, this data is combined with data collected by researchers using geolocators to estimate the mean number of days that shorebirds in the population spend in the study area during the study period. It may be shown that dividing the estimated mean number of shorebirds in the larger study area divided by the mean number of days a shorebird spends in a study area equals population size. Utilizing data from both types of surveys in a series of years permits estimating trend in size. For the Refuge conducting the on the ground surveys, a subtle problem arises in selecting the target universe. Suppose that birds feed at low tide in one area and then move to another area at high tide. It might be natural to survey the first areas at low tide and

the second at high tide. Yet if this were done, then the birds would be counted twice and the mean number of birds present in the study area would be badly over-estimated. To avoid this problem, the target universe is carefully defined to avoid consistent double-counting. Usually this means counting birds only at high tide, because in many cases they are easier to count then, but in some large areas (e.g., a State) decisions have been made to count them at low tide (also for practical reasons). Either approach may yield unbiased estimates but care is needed at the border between areas counted at high and low tides to avoid a situation in which birds in that area are consistently double-counted.

It is entirely feasible to design the target universe to meet both objectives. For example, a Refuge near the coast might have many more birds at high tide, when birds leave the coast for roosting areas on the Refuge. Refuge staff might want to conduct surveys at all times of day to document this pattern and submit the data to the ISS/PRISM program. The data will then be culled by analysts based on their criteria for determining trends in population.

The target universe should almost always be delineated on a map. The description of the target universe might be "Areas in Figure xx surveyed between 1 August and 30 September between 8:00 am and 5:00 pm and within two hours of a high tide."

Subset of the target universe available for sampling (sampled population)

In many studies, some areas cannot be surveyed (usually due to access issues). The question then arises whether they should be included in the target universe even though they cannot be selected for surveys. The issue to consider, in answering this question, is whether the inaccessible areas are likely to have substantially different numbers of shorebirds than the areas that can be surveyed. If this is likely, then these areas should be excluded from the target universe. For example, the administrative unit might include mainland and islands and far more shorebirds might be present on the islands. If the islands could not be surveyed, then they should be excluded from the target universe. On the other hand, if most islands can be surveyed and a few that cannot be surveyed have similar habitat to the others, then all the islands could be included in the target universe. Similar principles apply in defining the temporal dimension of the target universe. If surveys are conducted only on weekdays, but weekends are judged to have similar numbers of birds, then all days should be included in the target universe (e.g., so that bird use throughout the study period can be estimated). If numbers are substantially different on weekends (e.g., lower due to high human pressure) then weekends should be excluded from the target universe.

In deciding how much, if at all, the sampled population will differ from the target universe, keep in mind that areas that are difficult – but not impossible – to survey can be placed in one or more strata and sampled only occasionally. In the example above with mainland and islands, if the islands actually can be surveyed – but at much higher cost than the mainland - then islands might be placed in their own stratum and only a few surveys can be made in these areas. In general, this is a much better option than completely excluding hard-to-survey areas. The section below on designing sampling plans provides additional discussion of this issue.

Sampling plan and sample selection

Once the target population has been delineated, it must be sub-divided into plots, and – in many cases – plots must be assigned to strata. Once plots are defined, decisions must be made about

which ones will be surveyed and at what times. When the study area is fairly small, such as a Refuge, it may be obvious how plots should be delineated, and they may all be surveyed. For larger areas, such as the entire eastern coast of the US and Canada, a much more sophisticated process is needed. These steps have been carried out for many areas so there is no need to repeat them. If a sampling plan has not been defined for the target universe then we suggest contacting specialists in this kind of work associated with the ISS/PRISM project. The process, however, is briefly described below. We assume the target universe has been partitioned into plots.

a. In many studies, certain plots will definitely be surveyed because they are of high interest, someone is available who wants to survey the plot, or some other reason. These plots are all placed in one group called "to be surveyed" (TBS). Since they are all surveyed, there is no random selection within this group.

b. Next we sub-divide the remaining plots into two groups based on expected number of birds. We call these groups "high" and "other".

c. Next we consider whether regions should be considered. Regions are defined for practical reasons. For example, in one area, some of the beach was Department of Defense (DoD) land. A DoD employee said he could survey some randomly-selected plots on the DoD property but he couldn't justify surveying plots outside DoD land. The plots on DoD land were therefore assigned to their own region. Another reason for defining regions is that a surveyor may be available to survey plots within 10 km of their home, but not further away. In a fairly small administrative unit like a Refuge, regions would probably not be defined.

d. A table of all the plots in the sampled population is then prepared listing the region and birds for each plot and the plots are assigned to strata (see Table 2 for an example). Resources must be available to survey at least two plots in each stratum. These requirements often affect how regions and plots should be defined and the initial suggestions often have to be modified. Eventually, a table like the one below on the left is produced. Plots in this table are listed as they occur on the landscape (e.g., north to south).

e. Finally, a sample of plots in each stratum is selected. This is easiest to do if the list of plots is sorted by stratum as in the example below on the right. Selection within strata may be either simple random or systematic. Sample sizes within strata may be determined by first deciding on the total number of plots to be randomly selected (recalling that commitments have already been made to survey all plots in the TBS group) and distributing this sample so that more plots are selected in larger regions and in good habitat. Formulas can be used to estimate the optimal allocation of surveyed plots among strata, but the results differ for different species and seldom (in our experience) yield better plans than survey designers can produce using their intuition and careful consideration of a few alternatives.

f. Selecting survey times. Survey times should be selected systematically across the survey period to obtain even coverage. If the standard ISS protocol is being followed,

then each selected plot will be surveyed every ten days. In the large-scale ISS/PRISM project, plots may be surveyed only three times or even fewer if care is taken to select the survey time(s) in a manner that insures the mean number present throughout the study period is estimated without (selection) bias. It is very important to avoid conducting surveys at times selected because it is known that high numbers of birds will be present. For example, do not wait for particularly "good" weather conditions and conduct the surveys then. That would yield a highly biased estimate of the mean number of shorebirds present.

Table 3. All plots in the sampling area are assigned to a stratum based on shorebird use or management objectives.

PLOT	STRATUM	REGION	BIRDS	STRATUM	PLOT	REGION	BIRDS	SELECTED?
1	1	1	Good	1	1	1	Good	1
2	2	1	Other	1	4	1	Good	0
3	2	1	Other	1	6	1	Good	1
4	1	1	Good	2	2	1	Other	0
5	2	1	Other	2	3	1	Other	1
6	1	1	Good	2	5	1	Other	1
7	2	1	Other	2	4	1	Other	0
8	2	1	Other	2	8	1	Other	1
9	2	1	Other	2	9	1	Other	1
10	3	2	Other	3	10	2	Other	0
11	3	2	Other	3	11	2	Other	1
12	3	2	Other	3	12	2	Other	1
13	3	2	Other	3	13	2	Other	0

Sample size

For Refuge-specific projects, the needed sample size depends entirely on accuracy targets and variation in numbers of shorebirds between sampling units. If advance information is available on how these numbers vary between surveys, any statistician can offer advice on needed sample sizes.

The needed sample size depends entirely on the survey objectives. In the ISS/PRISM project, a good deal of attention has been given to this issue, and decisions are made based on a compromise between what cooperators can realistically deliver and accuracy targets. In most areas, designing a rigorous sampling plan, as described above, was much harder than getting the needed coverage. Several states, for example, were able to survey nearly all the plots in the initial target universe (which was for beach shorebirds). For the large-scale ISS/PRISM project, therefore, we recommend not worrying too much about sample sizes and contacting personnel working on the project for assistance in making final decisions.

Survey timing frequency

This issue was discussed in section 1 above, *Sampling unit*.

Standard Operating Procedure 2: Conducting Surveys

This protocol requires surveyors to count and record all shorebirds observed within the count area. Do not record target species only. Search the entire plot area, as delineated on the plot map, and record all shorebirds detected that were in the plot at the time the survey started. Any method may be used (e.g., boat, foot, vehicle, aerial) as long as the entire plot is covered.

Survey Timing – Among-year survey timing

Survey Option#1 (Preferred Option) –
Surveys are conducted during both spring and fall migrations (Table 3). Spring migration begins March 15th (or April 1st in northern states) and continues until June 15th (or June 5th in southern states; Table 3). Fall migration begins July 15th to October 25th. Winter surveys, if conducted, run from November 5th to March 14th. Surveys should be conducted on the recommended dates, or as close as possible +/- 3 days. Surveys are conducted every 10 day.

Table 4. Recommended survey dates throughout the spring and fall migration for preferred Option #1. Winter surveys are optional. Surveys are conducted at ten day intervals throughout migration periods or, if winter surveys are conducted, at any interval during the winter. Northern states should begin surveys on April 1st and southern states can stop spring migration surveys after June 5th.

STATES	SPRING	FALL	WINTER
Southern	March 15	July 15	November 5 - March 14
	March 25	July 25	
	April 5	August 5	
	April 15	August 15	
	April 25	August 25	
	May 5	September 5	
	May 15	September 15	
	May 25	September 25	
	June 5	October 5	
		October 15	
		October 25	
Northern	April 1	July 15	November 5 - March 14
	April 15	July 25	
	April 25	August 5	
	May 5	August 15	
	May 15	August 25	
	May 25	September 5	
	June 5	September 15	
	June 15	September 25	
		October 5	
		October 15	
		October 25	

In general, the more counts made at an ISS site and the longer the record of years, the more valuable a census series becomes as a scientific record. However, in the event that surveys cannot be conducted as frequently as described in Survey Option#1, two additional, least preferred options are described.

Survey Option#2 –
During spring migration, survey the site twice in April, twice in May and once in June between the 1st and 10th of the month (Table 4). Counts should be at least 1 week apart. (For those in the Southeast, survey your site once in March between the 15th and 31st of the month, twice in April and twice in May.)

During fall migration, survey the site once in July between the 11th and 31st, twice in August, twice in September and twice in October. Counts should be done at least one week apart.

Survey Option #3 -
During spring migration, survey the site three times between April 1st and June 10th (Table 4**).** The first count should be between April 1st and 23rd, the second between April 24th and May 16th and the third between May 17th and June 10th. In the Southeast, the first count should be between March 15th and April 6th, the second between April 7th and 29th and the third between April 30th and May 22nd. Counts should be at least 14 days apart.

During fall migration, survey the site three times between July 15th and October 15th. The first count should be between July 15th and August 15th, the second between August 16th and September 15th and the third between September 16th and October 15th. Counts should be done at least 14 days apart.

Table 5. Recommended survey dates and frequencies for Survey Options #2 and #3.

OPTION	STATES	DATES	SURVEY FREQUENCY	NOTES
#2	Southern	March 15th – 31st	once	All surveys should be conducted at least one week apart.
		April 1st – 31st	twice	
		May 1st – 31st	twice	
	Northern	April 1st – 30th	twice	All surveys should be conducted at least one week apart.
		May 1st – 31st	twice	
		June 1st – 15th	once	
#3	Southern	March 15th – April 6th	once	All surveys should be conducted at least 14 days apart.
		April 7th – 29th	once	
		April 30th – May 22nd	once	
	Northern	April 1st – 23rd	once	All surveys should be conducted at least 14 days apart.
		April 24th – May 16th	once	
		May 17th – June 15th	once	

Survey Timing – Within-year survey timing
At coastal sites, try to count at times when the survey will be most accurate. For some coastal sites the most accurate counts are conducted within 2 hours of high tide when birds gather at resting areas; for other sites, a better representation of the site may be within 2 hours of the low tides when birds are feeding.

Using a tide chart for the area nearest the site, record the tide at the beginning of the survey. Record the tide using the tide codes outlined in Table 5.

At inland sites or impoundments, the survey should be conducted at a time of day when shorebirds tend to be most active, depending on your prior knowledge of the site. At inland wetland sites (including lakes, ponds, etc.), indicate whether the water levels are Normal (N), High (H), or Low (L). At impoundments, indicate whether the water levels are Normal (N), High (H), or Low (L) or record the water level if a water level meter is installed.

Table 6. Tide codes used to designate tidal cycle at beginning of the survey. Adapted from Methods for monitoring migratory and wintering shorebirds in Southeast Coast Network Parks (Byrne et al. 2009).

TIDE CODE	DEFINITION
1	High (~1 hour before to ~1 hour after peak)
2	Almost high, and rising (~1.5 hours before high tide)
3	Almost high, and falling (~1.5 hours after high tide)
4	Hal-tide, rising (~2.5 hours before high tide)
5	Half- tide, falling (2.5 hours after high tide)
6	Almost low, rising (~1.5 hours after low tide)
7	Almost low, falling (~1.5 hours before low tide)
8	Low (~1 hour before to 1 hour after peak)
9	Not observed, not applicable, or observations made during more than one of these periods.

Observational Techniques

Each survey should be a count of all shorebird species observed and not just target species. Surveyors should attempt to record all shorebirds in the plot at the start of the survey. Birds that enter the plot after the survey begins, or that are outside the plot at the start of the survey, can be ignored or should be separately recorded as incidental sightings. If the plot is too large to see at a single time, then it may be sub-divided into compartments small enough that the surveyor can identify birds that leave during the survey (and are counted) or arrive after the survey begins (and are not counted). The surveyor only counts in one compartment at a time.

Many practical problems arise in conducting the surveys. Surveyors must be careful not to push birds ahead and then double-count them. Large, dense flocks are hard to count and may require training with visual aids. The surveyor should approach the site quietly and slowly to minimize surprising the birds. Scan the entire area immediately to obtain an estimate of number of birds, number of flocks and species composition. Obtain a quick estimate of total numbers of birds and the proportion of each species compared to the total. This is important so that if the birds are spooked and fly away, an estimate of each species can be calculated.

Systematically count the number of birds of each species using binoculars and/or a spotting scope. Accuracy of the count and correct identification of species is critical and addressed in the next sections.

Accuracy

At best it is difficult to count a thousand small sandpipers milling about on a beach. It is important to note whether the tally is an actual a count, an estimate made by a methodical procedure, or an educated guess. A systematically-made estimate is one where a count is made of one or more portions of a flock and then extrapolated to determine a total count. An educated guess ("guesstimate") is when you look at a flock and estimate the number of birds within the flock. On the data sheet, place an asterisk (*) next to a count tally; two asterisks (**) next to a extrapolated count; and three asterisks (***) next to the number if it is a "guesstimate".

Table 7. Accuracy of Count Code. Symbols are placed next to species survey count to indicate the level of count accuracy. Circle the number for a "guesstimate".

SYMBOL	ACCURACY OF COUNT
*	Counted
**	Extrapolated
***	Guesstimated

Species Identification

It may not be possible to identify all the shorebirds observed, especially in large mixed-species flocks. For example, a couple of Western Sandpipers in a large flock of 5,000 Semipalmated Sandpipers may be missed. This protocol requires that "identified" birds are recorded only if they have been identified. Therefore, a mixed-flock of 500 Sanderlings and other sandpipers gets recorded as 500 "peep sp" and not 500 Sanderlings. Resist the temptation to present accuracy that does not exist. If unsure of the species, get as close as possible to the species by using the definitions for "peep sp.","" large shorebird", "small plover sp." rather than include everything in "shorebird sp." (Table 7**).**

Table 8. The term and definition used to record unknown shorebird species.

TERM	DEFINITION/SCIENTIFIC NAME
small plover sp.	*Charadrius* sp (Wilson's/Killdeer/Semipalmated/Piping/Snowy)
Golden-plover sp.	*Pluvialis dominica/fulva*
plover sp.	*Charadriida* sp (small and large plover)
Greater/Lesser Yellowlegs	*Tringa melanoleuca/flavipes*
Short-billed/Long-billed Dowitcher	*Limnodromus griseus/scolopaceus*
peep sp.	the 5 small *Calidris* shorebirds (Semipalmated/Western/Least/White-rumped/Baird's)
large shorebird sp.	Scolopacidae sp. (larger shorebirds birds such as Willet//Dowitchers/Godwit/Curlew/Whimbrel/etc.)
shorebird sp.	all Charadriiformes sp.
phalarope sp.	*Phalaropus sp.*

Recording Variables

Record data on the ISS Survey Form (Supplementary Materials 2) or a modified Refuge data sheet. Use one form for each site. For ease of recording data, the survey form should be enlarged to fit a legal size (8.5" x 14") paper. Alternatively, species not found in the Refuge can be removed.

A Refuge may also choose to develop their own data form that includes additional information specific to their project or is of a format used in prior years. If this is the case, then the data form must include the required ISS data variables indicated in Table 8.

Table 9. Overview of survey data form required variables with the recording format and a brief definition.

VARIABLE	RECORDING FORMAT	DEFINITION
Year	yyyy	Survey year
Name	First Last	Surveyor's name
Email Address		Surveyor's email address
Location/Plot		Site name
Date	mm/dd	Survey date
Shorebird Species Observed	# of birds plus Accuracy Code	Survey counts
Count Type	Area, Traveling, Stationary	Type of survey conducted
Area	in acres	if conducting an Area survey
Distance Traveled	in miles	if conducting a Traveling Survey
Survey Start Time	in 24-hour time (hh:mm)	Time at start of survey
Survey End Time	in 24-hour time (hh:mm)	Time at end of survey
Tide (tidal sites)	circle one	Tide at start of survey
Water Level (non-tidal sites)	circle one	Water level at start of survey
Disturbance	circle one	Disturbance during survey

References

Byrne MW, DeVivo JC, Maxfield JM, Wright CJ, Thompson E. 2009. Methods for monitoring migratory and wintering shorebirds in Southeast Coast Network Parks. Natural Resource Report NPS/SECN/NRR—2009/107. National Park Service, Fort Collins, Colorado.

Standard Operating Procedure 3: Data Processing

Since the eBird database does not store covariate data along with the observational shorebird data, we are investigating means to store shorebird data in the Avian Knowledge Network (AKN) database. This SOP will provide detailed instructions for data entry, data validation and database administration, when data management procedures have been finalized. Currently, the SOP provides a general overview of the AKN.

Terminology

Using the database to enter or manage data requires knowledge of a few salient terms. In the AKN system:

- AKN Regional "Project Leader" = USFWS personnel assigned to oversee all AKN database permissions for the region, usually the Regional I&M Database Manager. This person is the liaison to AKN and sets access permissions to the database throughout the region. In this SOP we will refer to this role as the Regional "Project Leader" to denote that this is not the Refuge Project Leader.
- AKN Survey "Project Leader" = Survey Coordinator, usually the Refuge or Zone Biologist. This person can give permissions to field biologists and technicians for data entry and validation. This is the person that will be contacted if there are questions about the data and who has a commitment to the accuracy and the validity of data entered from your site. Throughout this SOP we will refer to this role as the Survey "Project Leader" to denote that this is not the Refuge Project Leader.
- Project = the name of the refuge, park, forest or other area over which a survey is conducted.
- Field Observer = the person or persons collecting data in the field via this protocol.
- Data Entry Technician = the person entering data collected via this protocol.

Gain Access to the Database

The Survey Coordinator is the refuge lead on the survey and will need to have database access permission from the Regional "Project Leader" before survey data for the refuge can be entered. He or she will assign, to a Survey "Project Leader" (Survey Coordinator), permissions for project creation, project access, and data entry. If this is an ongoing survey, the project should already exist in the AKN database.

Proof and Archive the Data Sheets

Data entry errors influence the quality and utility of collected data. However, many of these types of errors can be controlled through data organization, checking and entry techniques. The following steps should be used to reduce errors in the database and make original data recording materials available for future reference, back-up or checking.

1. Organize data sheets by survey unit to facilitate data upload. Proofread the data sheets ensuring that they have been filled out completely. If more than one person is collecting data, have someone that did not collect these particular data conduct the review.
2. Mark corrections on copied data sheets with red pen. Any corrected errors, or changes made by the data "proofer" (that are entered differently into the database than they appear

on the data sheet) should be circled, initialed, and corrected. Notes should be written in the margins or in the comments section whenever necessary to document the reason for the corrections.

3. Once reviewed and corrected, scan the data sheets to have a digital archive. If a portable computer or personal digital assistant (PDA) is used export the file into appropriate digital storage. The process and location of this back-up information should be specified in a site-specific survey protocol.
4. After data entry into AKN, archive the scanned data sheets or exported PDA file. If the data are associated with a survey report, include these data as an Appendix to the report and archive the report in ServCat. The original completed data forms or PDA file can also be stored on site in a safe place, preferably in a designated fireproof safe or cabinet.

Enter the Data

Prepare for data entry:

1. Organize your data and guidance materials to aid data entry process.
2. A data form will help verify that you have all the right data entry fields for your project.
3. A description or knowledge of the methods used for this survey.
4. The name and address of the Survey Coordinator (the person that can be contacted regarding questions about these data, once entered).

To enter the data into the AKN database:

1. Log on to the website and use your email address and password to access the data entry web site.
2. Enter allinformation from the datasheet into the database. The database is intended to accept data uploaded from handheld devices (PDA's), spreadsheets or stand-alone databases. Check with the Regional "Project Leader" or at the website to see when this will be available.
3. After all data from each data sheet have been entered or uploaded, proof the data in the database, reviewing the data forms and sorting summaries (from queries) to check for typos, errors, and blank fields. As each data sheet (or any PDA output) is proofed, date and initial that the input data were reviewed and checked against the original data records. The data entry person will also verify the data has been proofed in the database by changing the status of the data records to the next appropriate level (see the user's manual for the database).

Verify and Validate

In general, AKN uses a tiered set of levels for indicating the data validation and access. *<Briefly describe the levels of validation that are planned for IWMM data in AKN here or show a table or reference a user's manual>[To be added when available]*

Once the person entering data is finished, he or she needs to notify the Survey "Project Leader" that data are ready to be proofed in the database. The Survey "Project Leader" will:

1. Ensure all datasheets have been initialed.
2. Compare the data sheets with the data records in the database and if there are no errors, change the status of the records to the next appropriate level (see the user's manual for the database).

3. Discuss any questionable data entry or field observer errors with the Data Entry Technician and/or Field Observer. If there are errors, the Survey "Project Leader" will open up the records for editing.
4. After all errors are satisfactorily resolved in the database, the Survey "Project Leader" will change the status of the records in the database back to the next appropriate level (see the user's manual for the database).

Data Maintenance and Archiving

AKN is responsible for performing periodic backups of all data residing in the database. Editing of data that has already been "verified" in the database must be made in the AKN database by the Survey "Project Leader" via the interface. Contact the Regional Data Manager for assistance if numerous edits are needed. A detailed log identifying any changes to records already verified as correct and dates of the change must be maintained by the Survey Coordinator and stored along with the archived datasets in the annual reports stored in ServCat.

Table 12. Record style data need to be formatted. Be familiar with this formatting before the field season and train surveyors to record data as formatted to save time at the data entry step.

COLUMN HEADING	DESCRIPTION
Common Name	Species common name written according to Table 12
Genus	*Only required if not using Common Name*
Species	*Only required if not using Common Name*
Number	# birds observed or X (X=present); include species comments by adding a "pipe" (|) (e.g. " 200|estimated")
Location Name	ISS Site Name
Latitude	decimal degrees; *not required – will be able to indicate location after imported*
Longitude	decimal degrees; *not required – will be able to indicate location after imported*
Date	mm/dd/yyyy
Start Time	hh:mm AM/PM or 24-hour time with colon (hh:mm)
State/Province	Two letter code (e.g., NY, MA, TX)
Country Code	Two letter code (e.g., US, CA, MX)
Protocol	Stationary, Traveling, Casual, or Area.
Number of Observers	# people conducting survey
Duration	Convert to minutes. Start time- end time.
All Observations Reported?	Y = reported all birds seen; N = did not report all (e.g. only reported shorebirds)
Effort Distance Miles	In miles; *required for Traveling protocol*
Effort Area Acres	In acres; *required for Area protocol*
**Submission Comments	Add water level, disturbance, & tide data here (e.g. Water level = xxx; Disturbance = xx; Tide = xx); other comments (*no quotation marks allowed*); separate comments with a semi-colon (;).

** Water level, disturbance, and tide data must be entered under the Notes heading along with any other comments about the survey. If these variables were originally entered under their own column headings use spreadsheet formulas to quickly combine text from multiple columns into a single column. Formula suggestions for Microsoft Excel are given in the Supplemental Materials 1 section.

Table 13. Species names should be spelled out according the following list. If you are unsure of the species, try get as close as you can by using the definitions for "peep sp.","" large shorebird", "small plover sp." rather than lump everything in "shorebird sp".

ENTRY NAME	DEFINITION/SCIENTIFIC NAME
Black-bellied Plover	Pluvialis squatarola
American Golden-Plover	*Pluvialis dominica*
Pacific Golden-Plover	*Pluvialis fulva*
Snowy Plover	*Charadrius alexandrinus*
Wilson's Plover	*Charadrius wilsonia*
Semipalmated Plover	*Charadrius semipalmatus*
Piping Plover	*Charadrius melodus*
Killdeer	*Charadrius vociferus*
small plover sp.	= *Charadrius* sp (Wilson's/Killdeer/Semipalmated/Piping/Snowy)
Golden-plover sp.	*Pluvialis dominica/fulva*
plover sp.	= *Charadriida* sp (small and large plover)
American Oystercatcher	*Haematopus palliatus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Greater/Lesser Yellowlegs	*Tringa melanoleuca/flavipes*
Solitary Sandpiper	*Tringa solitaria*
Willet	*Tringa semipalmata*
Willet (Eastern)	*Tringa semipalmata semipalmata*
Willet (Western)	*Tringa semipalmata inornata*
Spotted Sandpiper	*Actitis macularius*
Upland Sandpiper	*Bartramia longicauda*
Whimbrel	*Numenius phaeopus*
Long-billed Curlew	*Numenius americanus*
Hudsonian Godwit	*Limosa haemastica*
Marbled Godwit	*Limosa fedoa*
Ruddy Turnstone	*Arenaria interpres*
Black Turnstone	*Arenaria melanocephala*
Surfbird	*Aphriza virgata*
Red Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*

ENTRY NAME	DEFINITION/SCIENTIFIC NAME
White-rumped Sandpiper	*Calidris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Stilt Sandpiper	*Calidris himantopus*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Short-billed/Long-billed Dowitcher	*Limnodromus griseus/scolopaceus*
peep sp.	= the 5 small *Calidris* shorebirds (Semipalmated/Western/Least/White-rumped/Baird's)
large shorebird sp.	= Scolopacidae sp. (larger shorebirds birds such as Willet//Dowitchers/Godwit/Curlew/Whimbrel/etc.)
shorebird sp.	= all Charadriiformes sp.
Wilson's Snipe	*Gallinago delicata*
American Woodcock	*Scolopax minor*
Wilson's Phalarope	*Phalaropus tricolor*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicarius*
phalarope sp.	*Phalaropus sp.*
Purple Sandpiper	*Calidris maritima*

Standard Operating Procedure 4: Data Analysis

These surveys are used mainly to estimate the mean number of birds present in the study area during the study period and to estimate trends in this mean, especially across a series of year. The methods used to estimate mean numbers present depend on whether all plots have been surveyed, as might be true at a Refuge, or not, as is true in the ISS or ISS/PRISM programs.

All plots in the target universe surveyed

If all plots in the target universe have been surveyed, then the only sampling is in time. If, in addition, all plots are surveyed on the same days, then we have one-stage systematic sampling. Such surveys are almost always treated as simple random samples. The estimated mean number present is simply the mean of the survey totals and the estimated standard error (SE) is the square root of the variance of the counts divided by the number of counts:

$$\hat{\bar{Y}}_{srs} = \frac{1}{m}\sum_{i}^{m} y_i$$

$$\widehat{SE}\left(\hat{\bar{Y}}_{srs}\right) = \sqrt{\frac{\sum(y_i - \bar{y})^2}{m(m-1)}}$$

where y_i is the total number of birds counted on all plots on the i^{th} day, $\bar{y}$ is the simple mean of the y_i, and m is number of survey days. These formulas are available in any introductory statistical methods text and can be solved using simple programs such as Microsoft Excel.

If all plots are surveyed, but not on the same days, then we have stratified sampling with plots as strata. In this case, we estimate the mean number of birds recorded in each plot (stratum) and sum the results:

$$\hat{\bar{Y}}_{st} = \sum_{i}^{n} \frac{1}{m_i} \sum_{j}^{m_i} y_{ij}$$

$$\widehat{SE}\left(\hat{\bar{Y}}_{st}\right) = \sqrt{\sum_{i}^{n} \frac{\sum\left(y_{ij} - \bar{y}_i\right)^2}{m_i(m_i - 1)}}$$

where y_{ij} is the number of birds recorded on the j^{th} survey of the i^{th} plot, $\bar{y}_i$ is the mean of these surveys, m_i is the number of times plot i was surveyed, and n is the number of plots. These formulas can easily be solved using a spreadsheet such as Microsoft Excel or with more sophisticated statistical packages such as SAS or a programming language such as R.

A sample of plots surveyed

If only some plots in the target universe are surveyed (and assuming plots are assigned to strata), then we have stratified random sampling. The formulas are similar to the ones immediately

above, but the strata are groups of plots and stratum sizes must be incorporated into the estimation process. The estimates are:

$$\hat{\bar{Y}}_{st} = \sum_{h}^{L} \frac{N_h}{n_h} \sum_{i}^{n_h} \bar{y}_{hi}$$

$$\widehat{SE}\left(\hat{\bar{Y}}_{st}\right) = \sqrt{\sum_{h}^{n} \frac{N_h^2 s^2(\bar{y}_{hi})}{n_h}}$$

where N_h is the total number of plots in stratum h, n_h is the number of plots in stratum h that were surveyed, $\bar{y}_{hi}$ is the mean number of birds recorded on the i^{th} plot in stratum h, and $s^2(\bar{y}_{hi})$ is the sample variance of the $\bar{y}_{hi}$. These estimates can also be calculated with a spreadsheet though more effort is required than for the cases above. One advantage of doing this, however, is that the user then knows exactly what is being calculated whereas this may be less certain with statistical packages. This problem does not arise with a programming language such as R because the code is then retrievable.

Trend estimation

A large literature, recently reviewed by Gitzen et al. (2012) exists on methods for estimating trends with counts such as the ones above. A very simple program was introduced recently by Bart and Thomas (unpublished manuscript) that estimates trends from data collected using all three approaches described above.

References

Gitzen RA, Millspaugh JJ, Cooper A, Licht DS. 2012. Design and analysis of long-term ecological monitoring studies. Cambridge University Press, UK

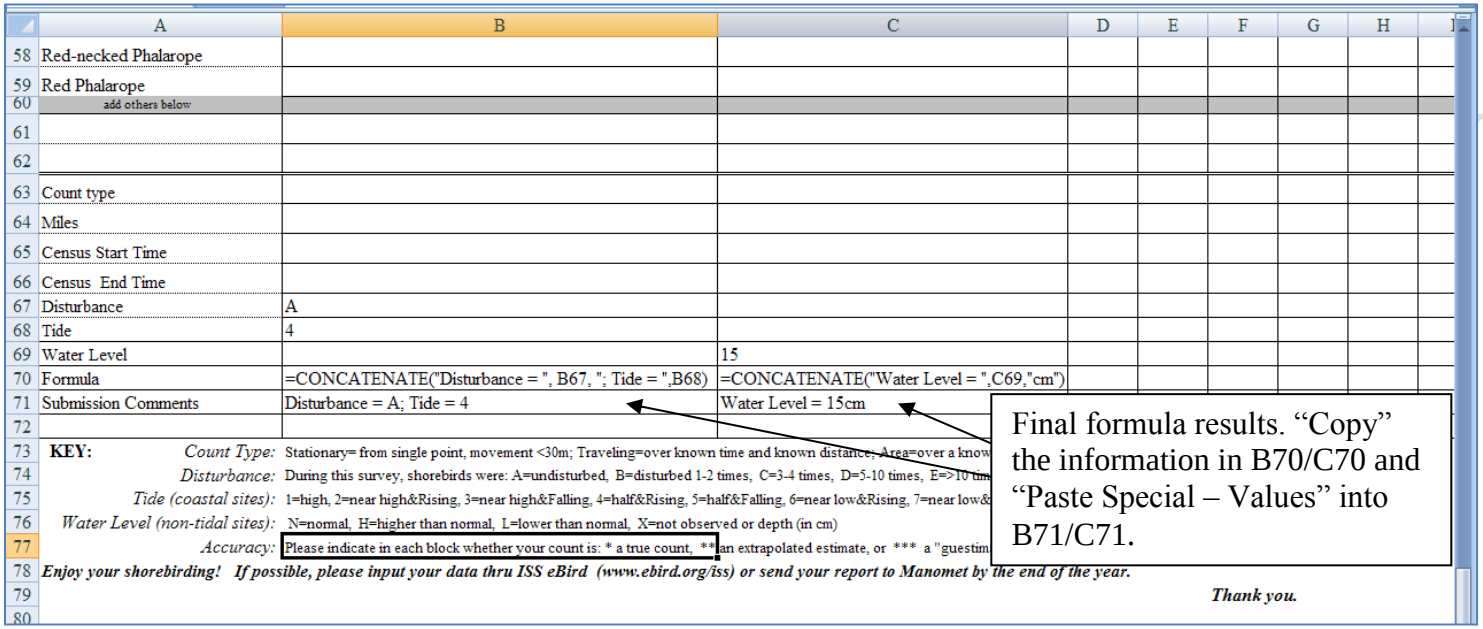
Supplemental Materials 1: Formatting tips for Excel

In this appendix are formulas to create the Submission Comments/Notes fields in the Record or Checklist Import formats and to help determine Duration.

The CONCATENATE Function

If you have entered your data into a spreadsheet with columns for each variable, you will have to condense the water level/disturbance/tide data and count accuracy data so that it will fit into the Comments sections. ISS eBird does not have separate columns for these variables at this time.

The easiest way to condense several columns into one column and to add text is to use the CONCATENATE function in Excel. Below is an example formula.



	A	B	C
58	Red-necked Phalarope		
59	Red Phalarope		
60	add others below		
61			
62			
63	Count type		
64	Miles		
65	Census Start Time		
66	Census End Time		
67	Disturbance	A	
68	Tide	4	
69	Water Level		15
70	Formula	=CONCATENATE("Disturbance = ", B67, "; Tide = ",B68)	=CONCATENATE("Water Level = ",C69,"cm")
71	Submission Comments	Disturbance = A; Tide = 4	Water Level = 15cm
72			
73	**KEY:** *Count Type:*	Stationary= from single point, movement <30m; Traveling=over known time and known distance; Area=over a know	
74	*Disturbance:*	During this survey, shorebirds were: A=undisturbed, B=disturbed 1-2 times, C=3-4 times, D=5-10 times, E=>10 tim	
75	*Tide (coastal sites):*	1=high, 2=near high&Rising, 3=near high&Falling, 4=half&Rising, 5=half&Falling, 6=near low&Rising, 7=near low&	
76	*Water Level (non-tidal sites):*	N=normal, H=higher than normal, L=lower than normal, X=not observed or depth (in cm)	
77	*Accuracy:*	Please indicate in each block whether your count is: * a true count, ** an extrapolated estimate, or *** a "guestim	
78	***Enjoy your shorebirding! If possible, please input your data thru ISS eBird (www.ebird.org/iss) or send your report to Manomet by the end of the year.***		
79			***Thank you.***
80			

Figure 2. Example of the CONCATENATE function using the ISS survey form.

1. Insert a row (if using Checklist format) or column (if using Record format) into your data. Paste or write the appropriate formula into this row/column (change the column & row numbers to reflect your data). Formula examples are as follows:
Disturbance,Water level,&Tide data: = CONCATENATE("Disturbance=",B67, "; Tide=",B68, "; Water level=",B69)
Disturbance & Tide data: = CONCATENATE("Disturbance=",B67, "; Tide=",B68)
Disturbance & Water Level: = CONCATENATE("Disturbance=",B67, "; Water level=",B69)

2. “Copy” the result from the formula row/column

3. “Paste Special→Values” into your final Notes/Comments column

4. Delete the formula row/column before uploading.

Calculate Survey Duration in minutes
This formula is for calculation of survey duration given a start and end time in in either AM/PM time or 24-hour time.

	A	B	C	D	E
61					
62					
63	Count type				
64	Miles				
65	Census Start Time	11:00 AM	11:00		
66	Census End Time	1:15 PM	13:15		
67	Disturbance				
68	Tide				
69	Water Level				
70					
71	Formula	=(B66-B65)*24*60	=(C66-C65)*24*60		
72	Duration (in Minutes)	135	135		
73					

Figure 3. Example of the formula to calculate duration (in minutes) using the ISS survey form.

The steps for this calculation are as follows:

1. Create a Formula row and format the formula cell (e.g. B71/C71) as a number.

2. The formula is (End time – Start time)*24*60. Apply same formula to AM/PM time or to 24-hour time.

3. "Copy" the results of the Formula and "Paste Special → Values" into your final *Duration (in minutes)* row (e.g. B72/C72).

4. Delete the Formula row before submitting.

Split Text into Separate Columns

When you download your data, Notes/Comments column will contain a string of text consisting of the disturbance, tide, water level, and comments information. It is easy to split these comments fields so that each piece of information is in its own column as long as you remembered to separate comments by a semi-colon(;).

1. Insert extra columns besides the Notes/Comments field.

2. Highlight the Notes/Comments field.

3. Apply "Text to Columns" in the Data tab.

4. Choose "Delimited" by a *semi-colon (;).*

5. Data are now in separate columns.

Supplemental Materials 2: ISS Survey Form

The ISS/PRISM Survey Form is formatted for legal sized paper (8 ½" x 14") (Figure 13). This form can be modified by the Refuge as necessary; however, all variables should be included on the new form. One suggestion for modifying this form is to remove shorebird species not typically found on the refuge.

INTERNATIONAL SHOREBIRD SURVEYS (ISS)
c/o Manomet Center for Conservation Sciences, Box 1770, Manomet, MA USA 02345

Year_____ Page _____

Name:_____ Survey Area _____
(Please use separate forms for different survey localities.)

Address _____
(Address needed only on pg. 1)

DATE (mm/dd)-->													
Black-bellied Plover													
American Golden-Plover													
Pacific Golden-Plover													
Snowy Plover													
Wilson's Plover													
Semipalmated Plover													
Piping Plover													
Killdeer													
American Oystercatcher													
Black-necked Stilt													
American Avocet													
Greater Yellowlegs													
Lesser Yellowlegs													
Greater/Lesser Yellowlegs													
Solitary Sandpiper													
Willet													
Willet (Eastern)													
Willet (Western)													
Spotted Sandpiper													
Upland Sandpiper													
Whimbrel													
Long-billed Curlew													
Hudsonian Godwit													
Marbled Godwit													
Ruddy Turnstone													
Black Turnstone													
Surfbird													
Red Knot													
Sanderling													
Semipalmated Sandpiper													
Western Sandpiper													
Least Sandpiper													
peep sp.													
White-rumped Sandpiper													
Baird's Sandpiper													
Pectoral Sandpiper													
Dunlin													
Stilt Sandpiper													
Buff-breasted Sandpiper													
Short-billed Dowitcher													
Long-billed Dowitcher													
Short-billed/Long-billed Dowitcher													
Wilson's Snipe													
American Woodcock													
Wilson's Phalarope													
Red-necked Phalarope													
Red Phalarope													
Count type													
Area (acres)													
Distance Traveled (miles)													
Survey Start Time													
Survey End Time													
Disturbance													
Tide													
Water Level													

KEY: *Count Type:* Stationary= from single point, movement <30m; Traveling=over known time and known distance; Area=over a known area (hectares or acres).
Disturbance: During this survey, shorebirds were: A=undisturbed, B=disturbed 1-2 times, C=3-4 times, D=5-10 times, E=>10 times, X= unknown
Tide (coastal sites): 1=high, 2=near high&Rising, 3=near high&Falling, 4=half&Rising, 5=half&Falling, 6=near low&Rising, 7=near low&Falling, 8=Low, 9=unknown.
Water Level (non-tidal sites): N=normal, H=higher than normal, L=lower than normal, X=not observed or depth (in cm) _____
Accuracy: Please indicate in each block whether your count is: * a true count, ** an extrapolated estimate, or *** a "guestimate"

Enjoy your shorebirding! Please input your data thru ISS eBird (www.ebird.org/iss) or send your report to Manomet by the end of the year. Thank you!

Figure 4. The ISS Survey Form prints best on legal size (8.5" x 14") paper.

Supplemental Materials 3: List of Helpful Websites

AKN ISS site…

ISS Home Page: http://www.manomet.org/programs/shorebird-conservation/international-shorebird-survey-iss . Protocols, Survey Forms, maps and news are found here.

The U.S. Shorebird Plan PRISM site: http://www.shorebirdplan.org/science/program-for-regional-and-international-shorebird-monitoring/ . Additional information on the ISS/PRISM program at the national level.